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Climate Change Impacts on Ecosystem Services in California

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Presentation Outline

- Ecosystem services overview
- Ecosystem service production impacts under climate change
- Ecosystem service valuation
- Biodiversity impacts
- Summary and next steps

Goal of Project

To assess the potential impacts of climate change on ecosystem services and their associated economic value in California.

What are ecosystem services?

" Ecosystem services are the benefits people obtain from ecosystems"

-*Millennium Ecosystem Assessment, 2005*

ecosystem services

Supporting
- NUTRIENT CYCLING
- SOIL FORMATION
- PRIMARY PRODUCTION

Provisioning
- FOOD
- FRESHWATER
- WOOD AND FIBER
- FUEL

Regulating
- CLIMATE REGULATION
- FLOOD REGULATION
- DISEASE REGULATION
- WATER REGULATION

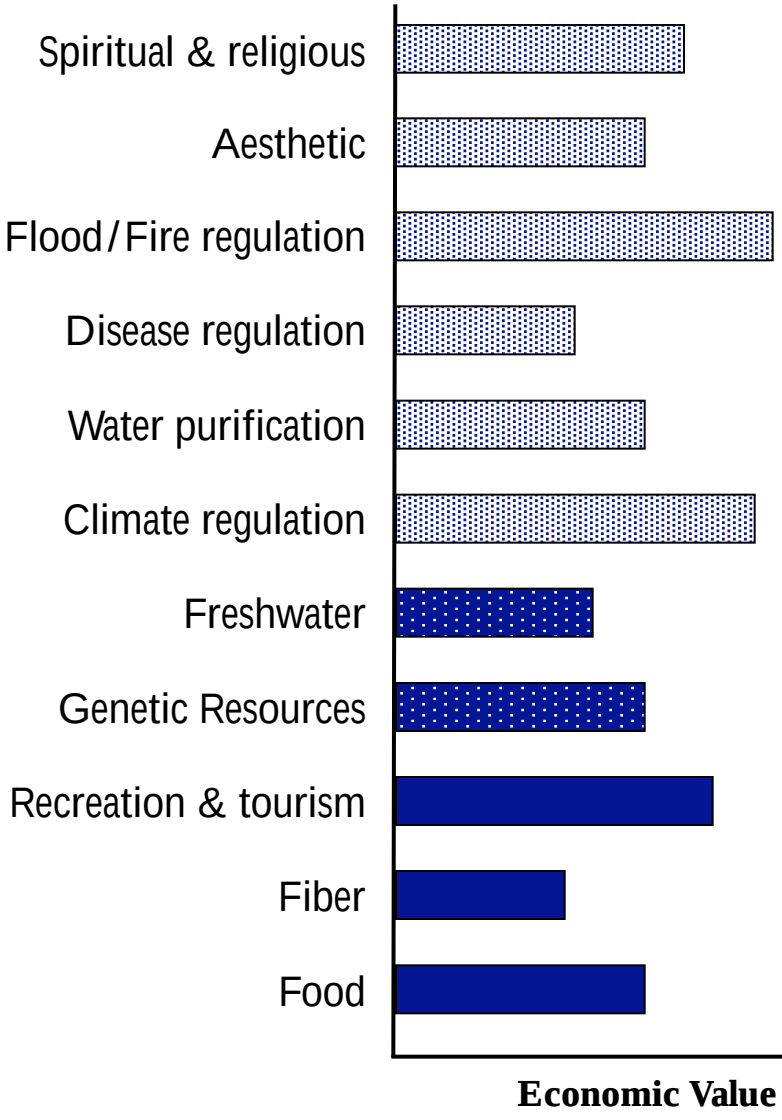
Cultural
- AESTHETIC
- SPIRITUAL
- EDUCATIONAL
- RECREATIONAL

Source: Millennium Ecosystem Assessment

ecosystem service production

- Pollination of crops
- Carbon sequestration
- Water quantity and timing of flow
- Regulation of floods
- Timber production
- Fish production
- Forage Production

ecosystem service valuation



Economic Valuation

Difficult or impossible

Possible

Ecosystem Services Types Evaluated

1. Ecosystem services for which we have *well-developed estimates* of ecosystem change and economic valuation
   - *Carbon sequestration*
   - *Forage production*

2. Ecosystem services for which we have *only a preliminary understanding* of the ecosystem change and economic impact
   - *Water quantity for instream flow for salmon production*
   - *Water quantity for recreational skiing*

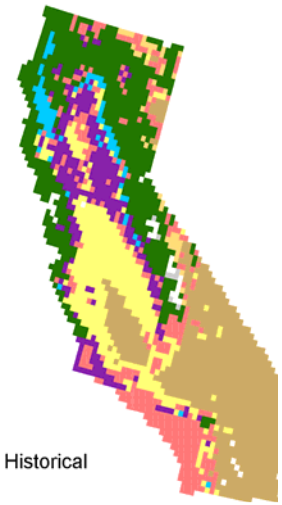
3. Biodiversity that underpins the production of many ecosystem services on which California depends.

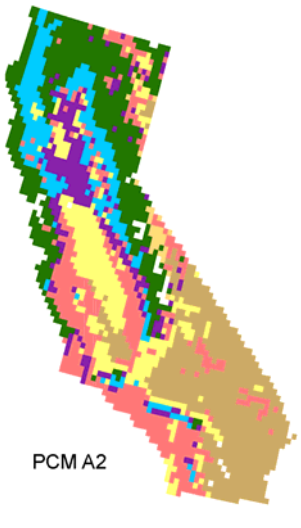
Bracketing potential impact spatially

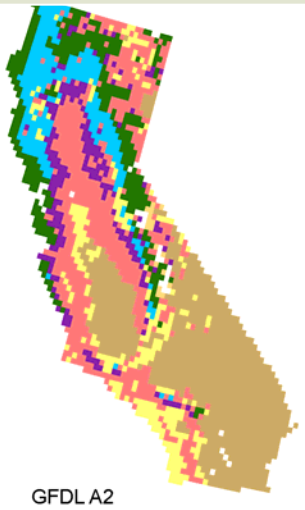
- Spatial changes for a future without climate change
- Two greenhouse gas emissions scenarios of climate change (low, optimistic B1 and high, business-as-usual A2)
- Three general circulation models
  - Parallel Climate Model (PCM) - a warm and wet future
  - Geophysical Fluid Dynamics Laboratory (GFDL) - hot and dry future
  - Community Climate System Model (CCSM3) - hot and dry future

Ecosystem Impact model

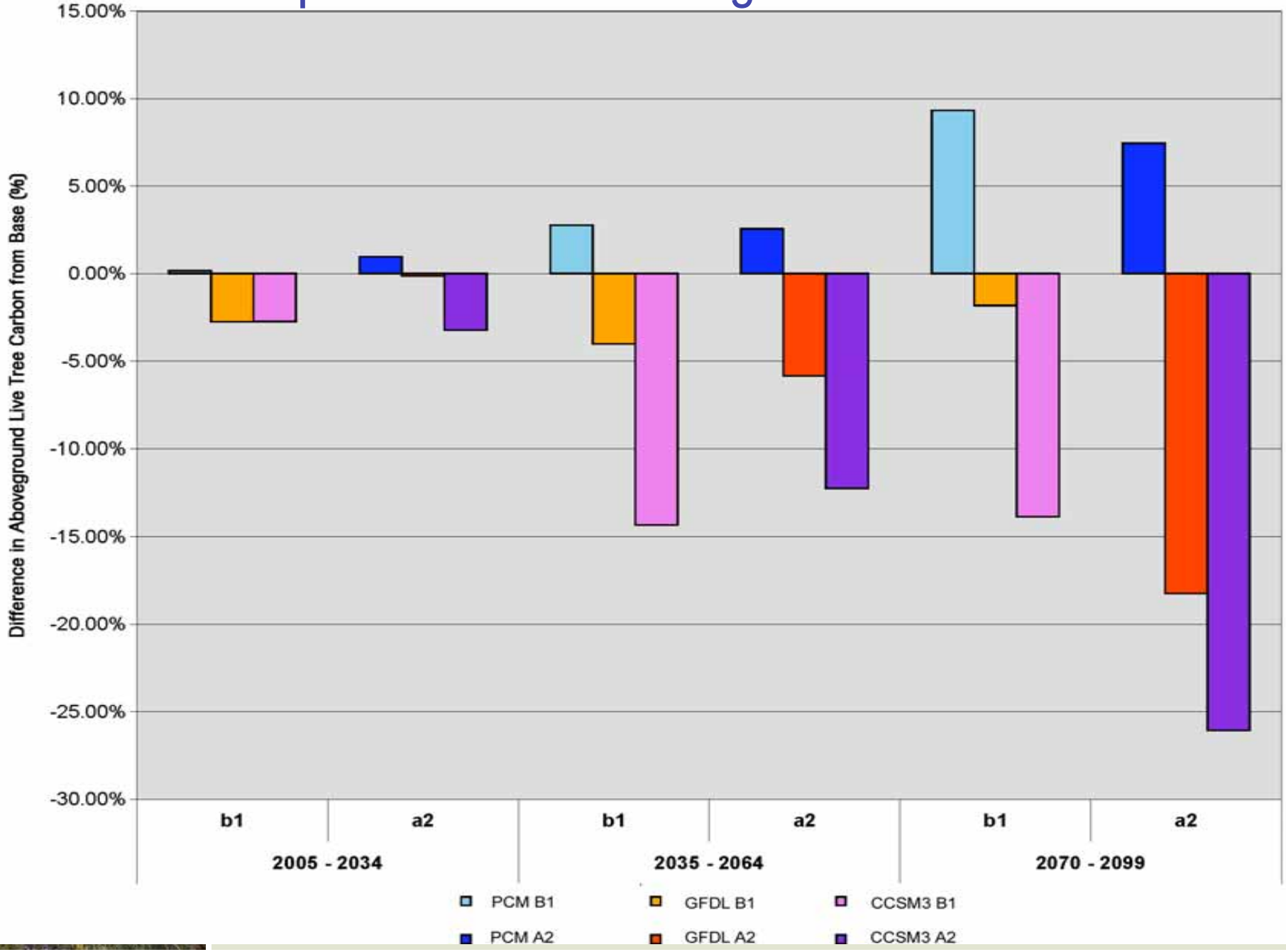
- Dynamic global Vegetation Model MC1
  - %15 to 70% increase in shrublands
  - A consistent decline in conifer woodland, conifer forest and herbaceous cover
  - Hot, dry GFDL: increase in shrubland, desert shrubland, and hardwood forest
  - Warmer, wetter PCM1 : less pronounced





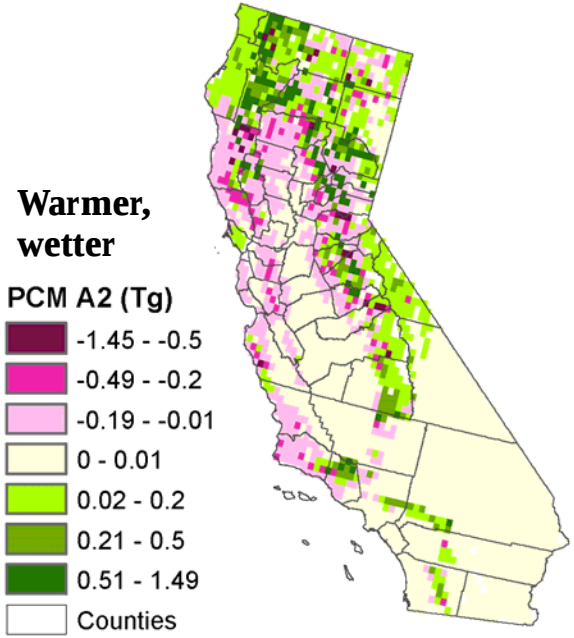


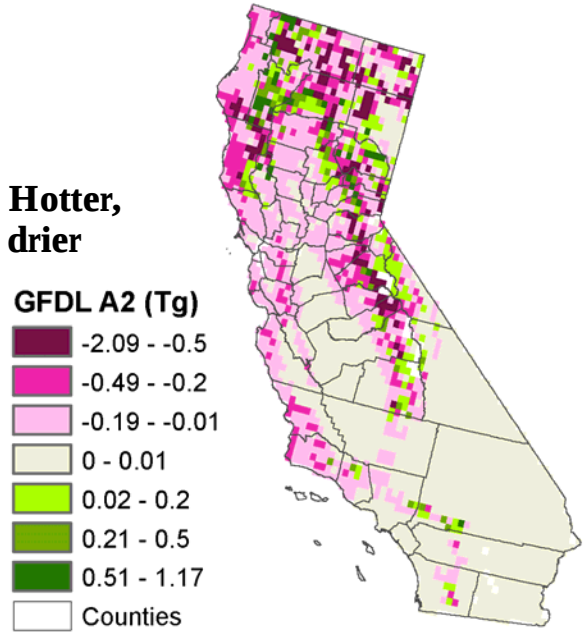
Carbon sequestration - aboveground carbon

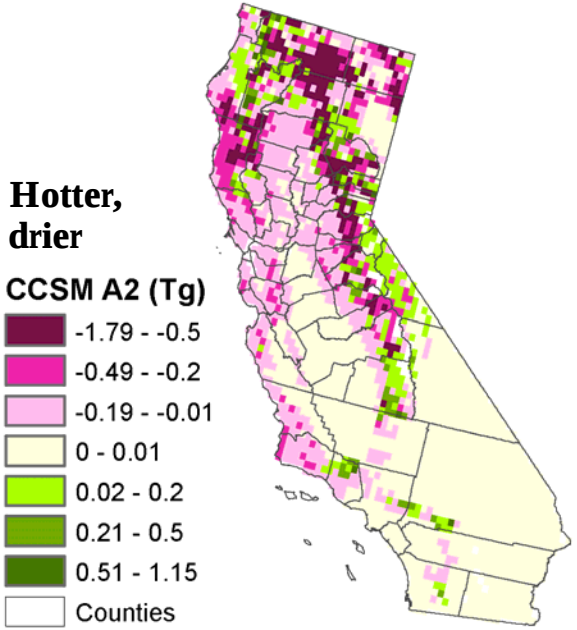


Carbon sequestration - aboveground carbon

- 1,025 Tg C in aboveground live tree biomass
- Loss of 15% under A2, hot/dry
- Increase of 3% under A2, warm wet

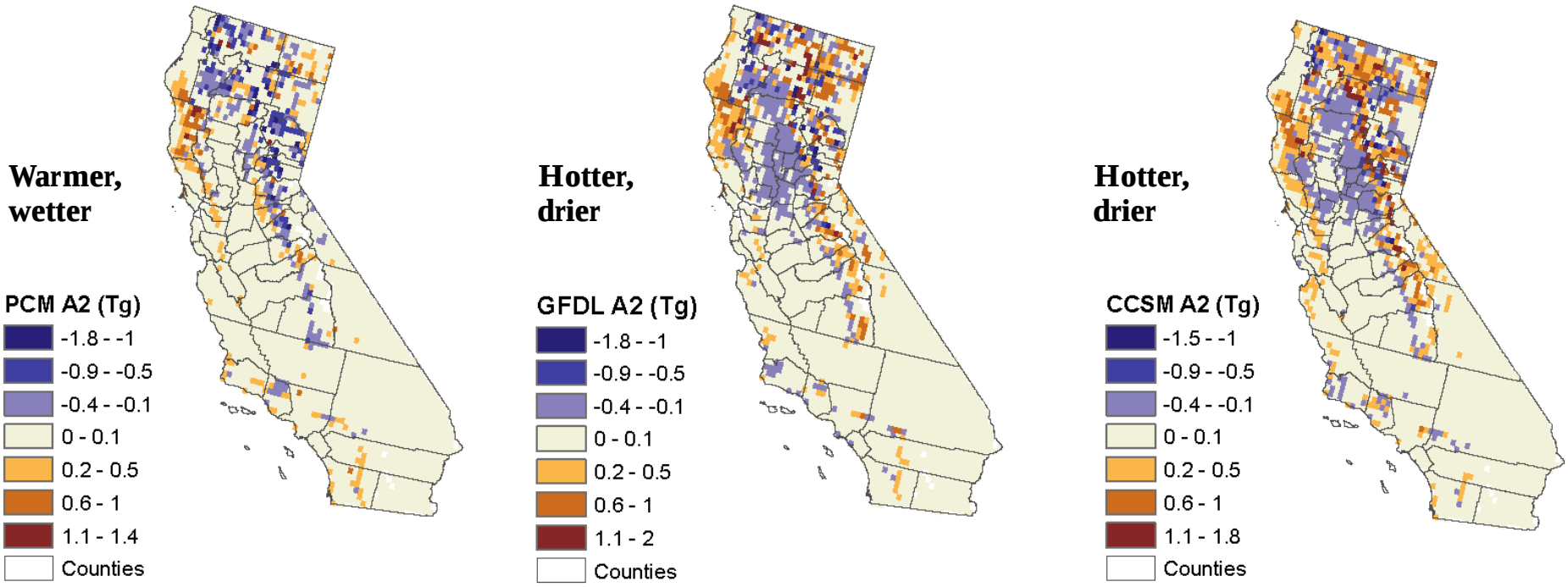






Net change in aboveground live tree carbon stored by the end of the century (2070–2099 mean)

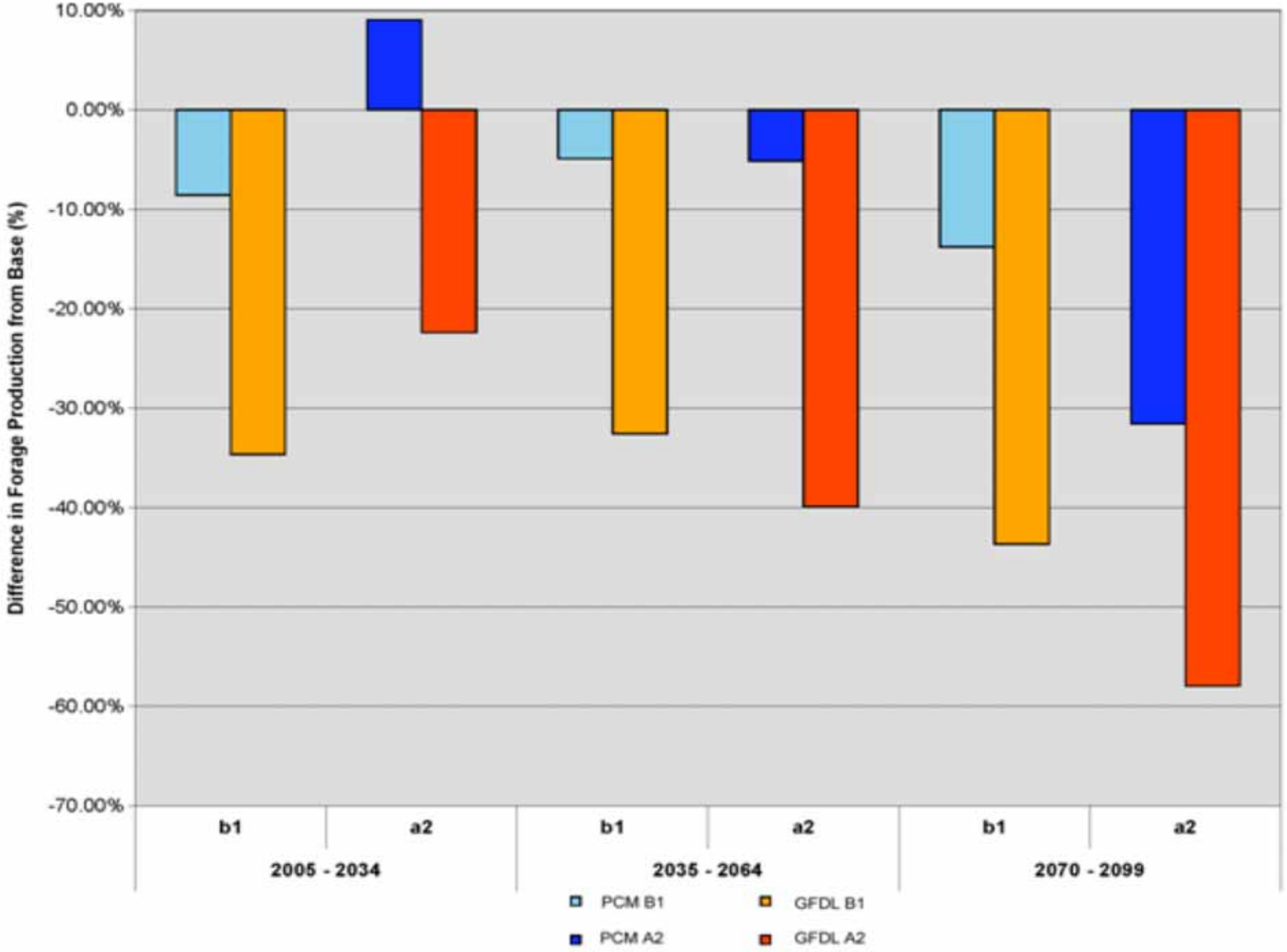
Carbon sequestration – aboveground carbon loss due to fire



Net change in carbon in biomass consumed by fire by the end of the century (2070–2099 mean)

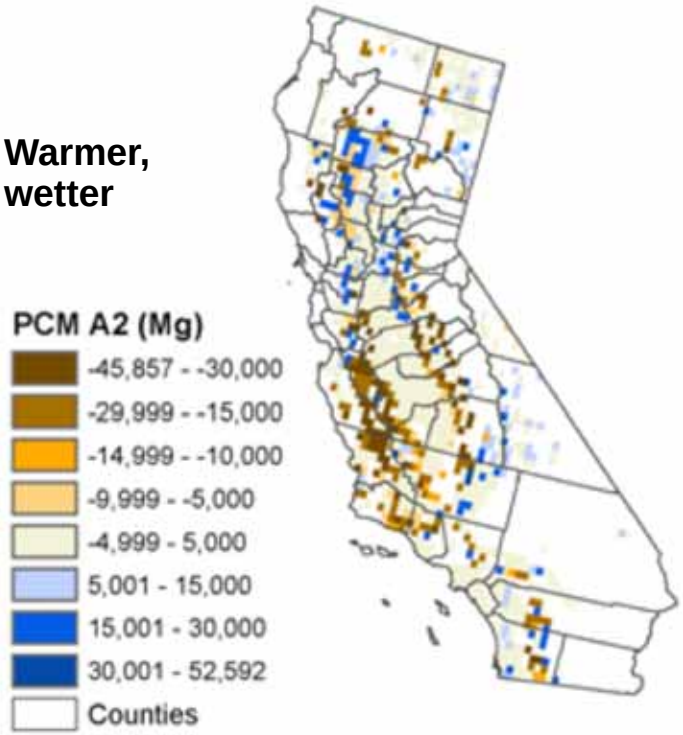
PCM1 climate conditions generating the smallest

Forage production - aboveground carbon

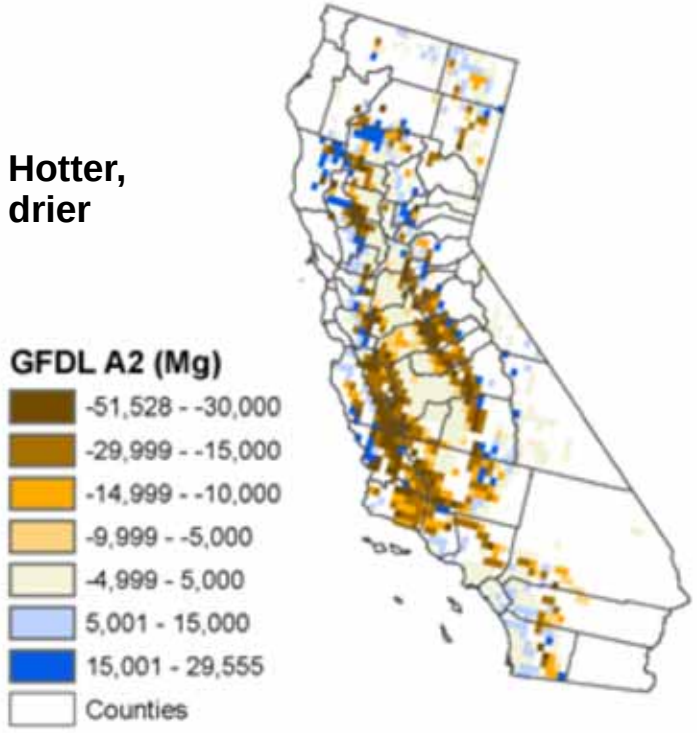


Forage production - aboveground carbon

Warmer, wetter

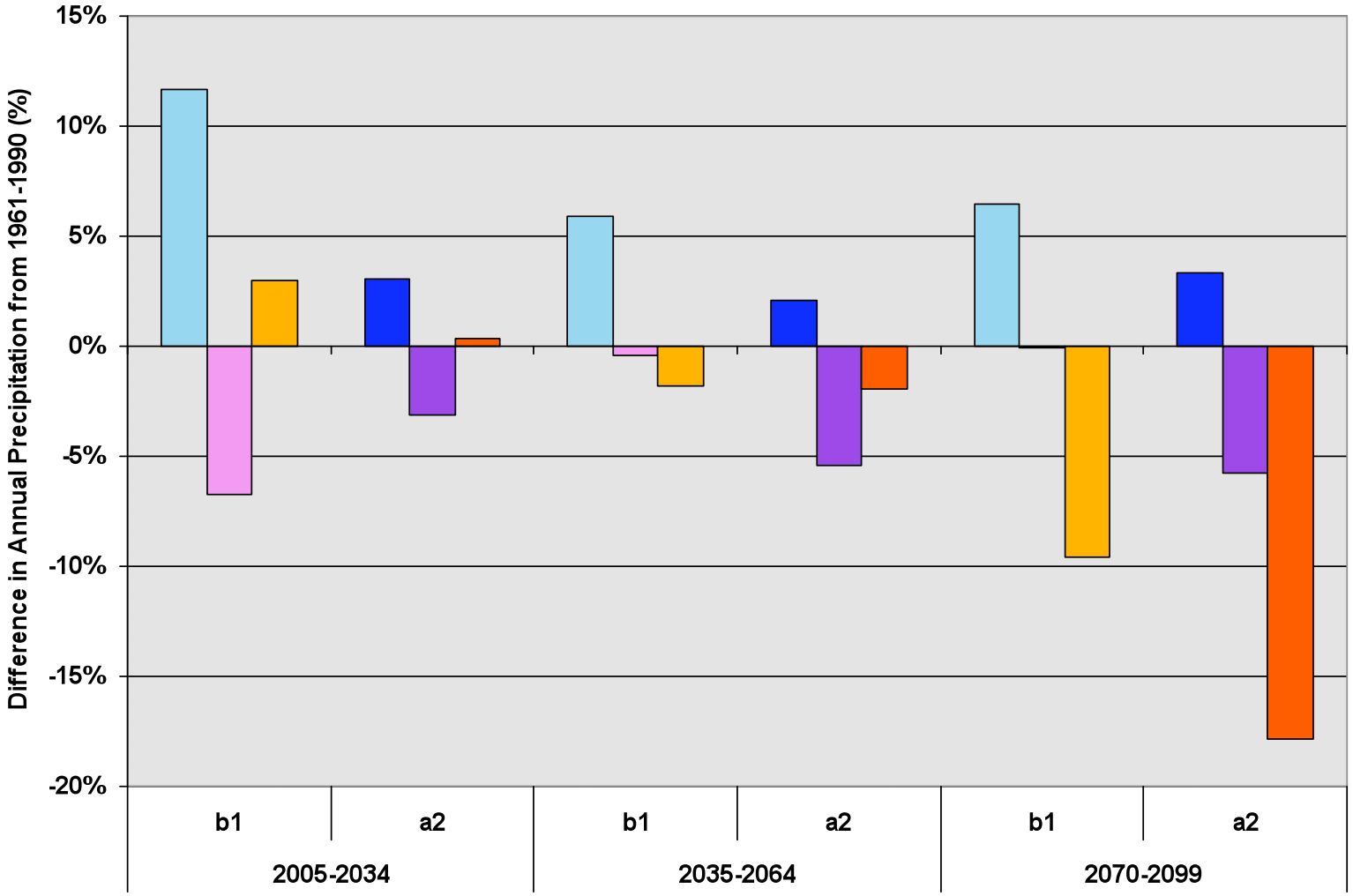


Hotter, drier

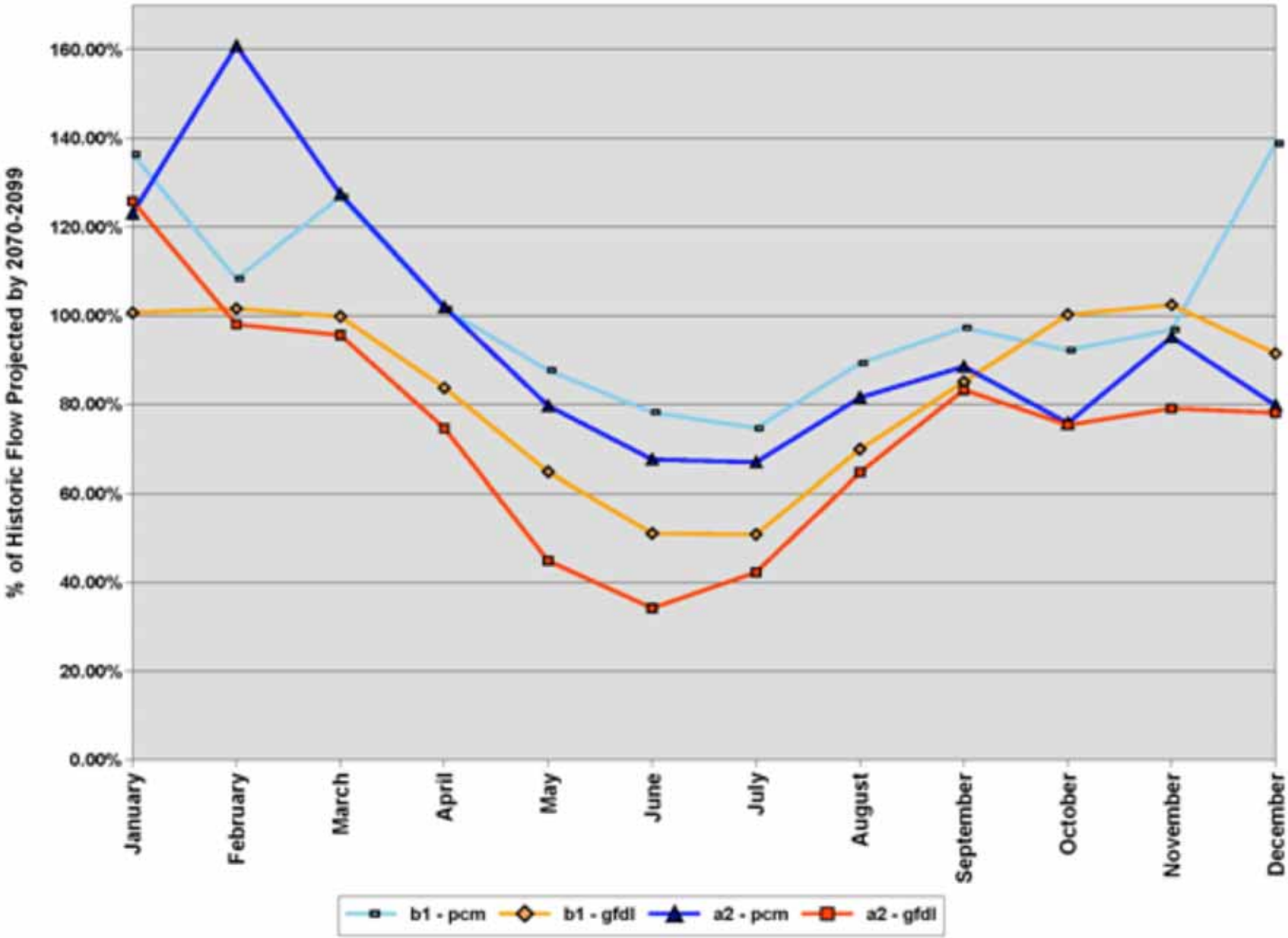


Net change in aboveground carbon in forage stored by the end of the century (2070–2099 mean)

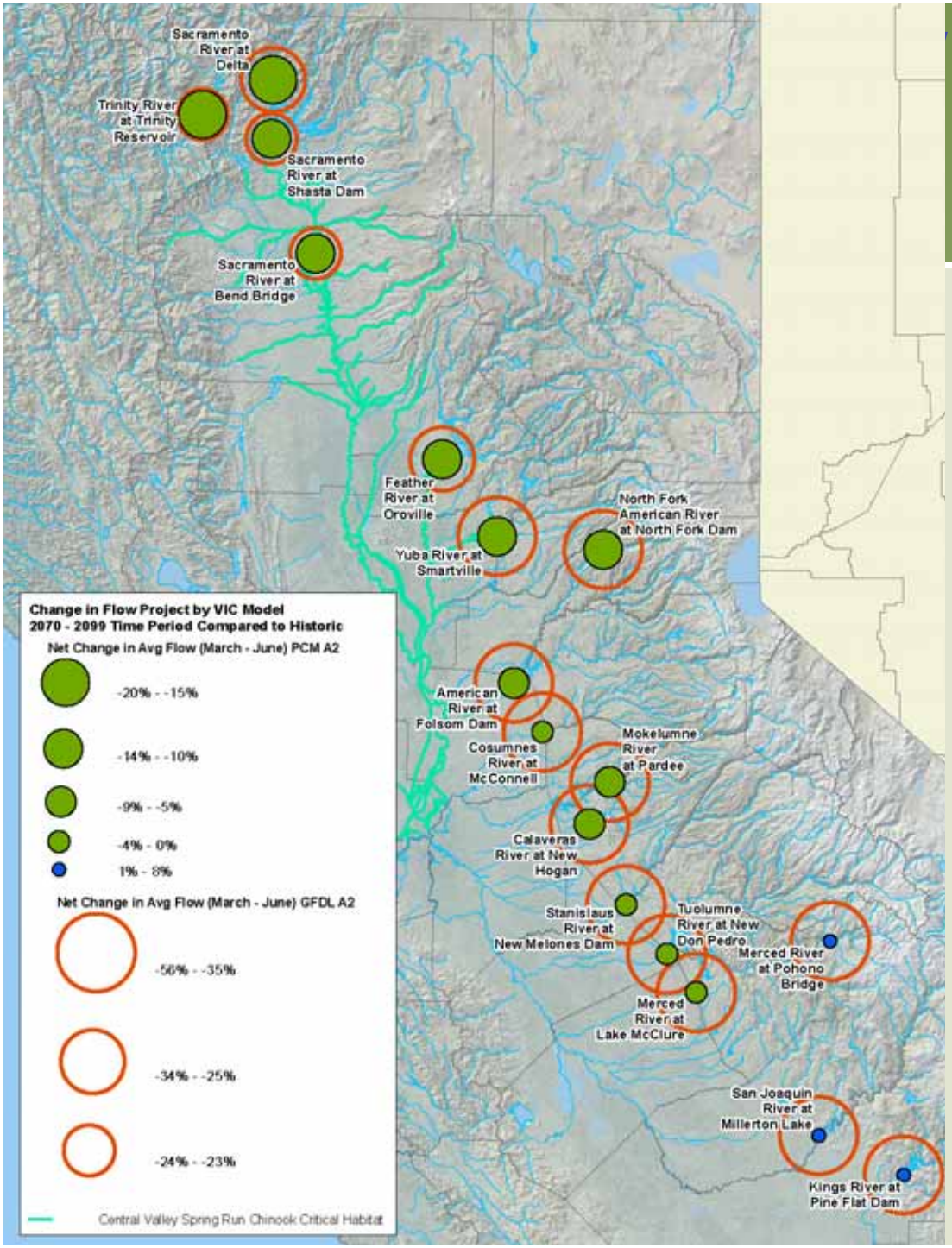
Precipitation changes



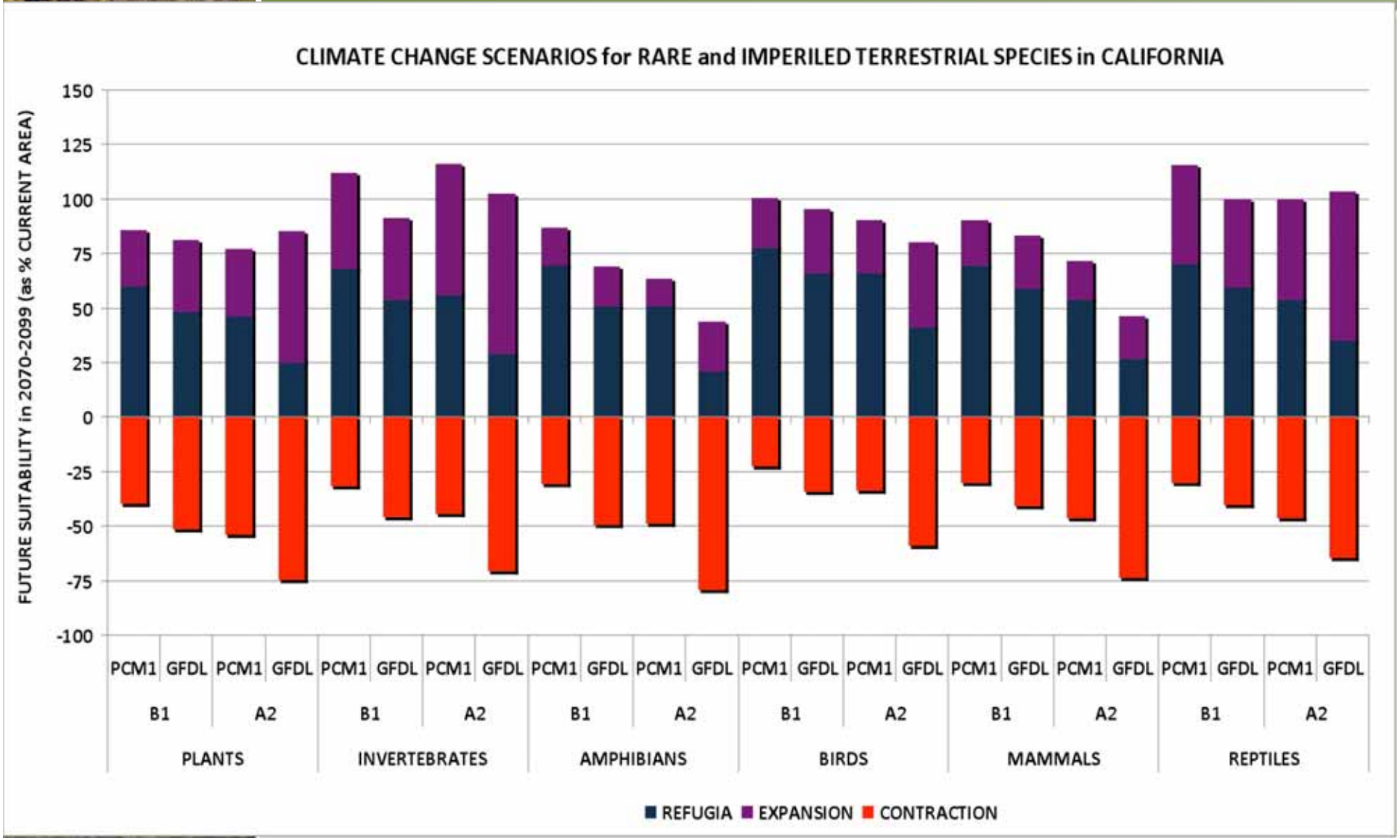
Projected Stream flow



Projected stream flow



Biodiversity: Rare and endangered species



Carbon and forage valuation

	Contribution of Ecosystem Service to Market Value, Revenues, or Profits					
	Current ($ million)	2005-2034 ($ million)		2035-2064 ($ million)		2070-2099 ($ million)	
		low	high	low	high	low	high
Carbon (carbon trading market values)							
Low emissions scenario							
Warmer Wetter (PCM1)		19	146	327	2,541	1,021	7,926
Hotter Drier (GFDL and CCSM3)		-323	-2,524	-475	-13,145	-199	-11,769
High emissions scenario							
Warmer Wetter (PCM1)		115	891	304	2,357	815	6,327
Hotter Drier (GFDL and CCSM3)		-15	-2,950	-690	-11,223	-1,994	-22,129
Carbon (net social costs)							
Low emissions scenario							
Warmer Wetter (PCM1)		38	303	655	5,271	2,044	5,271
Hotter Drier (GFDL)		-646	5,236	-950	-27,269	-399	– 24,413
High emissions scenario							
Warmer Wetter (PCM1)		230	1,847	608	4,890	1,632	13,125
Hotter Drier (GFDL and CCSM3)		-31	6,119	-1,381	23,281	-3,992	– 45,904
Forage (contribution to profits)							
Low emissions scenario							
Warmer Wetter (PCM1)		-14	-47	-8	-26	-22	-74
Hotter Drier (GFDL)		-56	-191	-50	-170	-70	-235
High emissions scenario							
Warmer Wetter (PCM1)		15	50	8	-27	-50	-170
Hotter Drier (GFDL and CCSM3)		-36	-123	-62	-208	-92	-312

Fishing and skiing valuation

	Contribution of Ecosystem Service to Market Value, Revenues, or Profits						
	Current ($ million)	2005-2034 ($ million)		2035-2064 ($ million)		2070-2099 ($ million)	
		low	high	low	high	low	high
Skiing (expenditures by skiers)							
	500	-	-	-	-	-	-
Skiing (non-market recreational value)							
	174	-	-	-	-	-	-
Commercial Fishing (revenues)							
(gross revenues)	13	-	-	-	-	-	-
(net revenues, 2005/2006)	-5	-	-	-	-	-	-
Recreational Fishing (expenditures by anglers)							
	20	-	-	-	-	-	-
Recreational Fishing (non-market recreational value)							
	20	-	-	-	-	-	-

We are largely ignorant of the value of ecosystem services to the California economy and even less knowledgeable about the ways in which climate change will affect these services and how California can best adapt to these changes.

Summary

- Small changes in ecosystem productivity can have large changes in the value of the ecosystem service
- Some of the value shared globally, while many are critical to Californians alone
- Data availability prevents critical evaluation of other services

Next steps

- Develop models linking climate change to ecosystem function and output
- Conduct valuation studies to fill gaps in our understanding future value of ecosystem services and how these values and economic behaviors could change in the future.
- Develop linked and integrated models of climate, ecosystem function, ecosystem services output, economic impacts and management options.
- Incorporate ecosystems service information in adaptation planning